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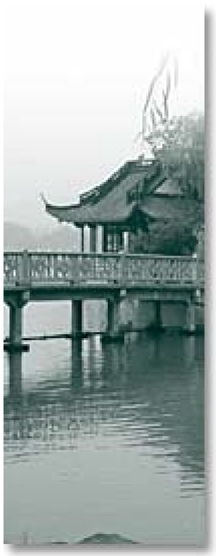

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Estimation of global snow cover using passive microwave data

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ABSTRACT

This paper describes an approach to estimate global snow cover using satellite passive microwave data. Snow cover is detected using the high frequency scattering signal from natural microwave radiation, which is observed by passive microwave instruments. Developed for the retrieval of global snow depth and snow water equivalent using Advanced Microwave Scanning Radiometer EOS (AMSR-E), the algorithm uses passive microwave radiation along with a microwave emission model and a snow grain growth model to estimate snow depth. The microwave emission model is based on the Dense Media Radiative Transfer (DMRT) model that uses the quasi-crystalline approach and sticky particle theory to predict the brightness temperature from a single layered snowpack. The grain growth model is a generic single layer model based on an empirical approach to predict snow grain size evolution with time. Gridding to the 25 km EASE-grid projection, a daily record of Special Sensor Microwave Imager (SSM/I) snow depth estimates was generated for December 2000 to March 2001. The estimates are tested using ground measurements from two continental-scale river catchments (Nelson River and the Ob River in Russia). This regional-scale testing of the algorithm shows that for passive microwave estimates, the average daily snow depth retrieval standard error between estimated and measured snow depths ranges from 0 cm to 40 cm of point observations. Bias characteristics are different for each basin. A fraction of the error is related to uncertainties about the grain growth initialization states and uncertainties about grain size changes through the winter season that directly affect the parameterization of the snow depth estimation in the DMRT model. Also, the algorithm does not include a correction for forest cover and this effect is clearly observed in the retrieval. Finally, error is also related to scale differences between *in situ* ground measurements and area-integrated satellite estimates. With AMSR-E data, improvements to snow depth and water equivalent estimates are expected since AMSR-E will have twice the spatial resolution of the SSM/I and will be able to characterize better the subnivean snow environment from an expanded range of microwave frequencies.

Keywords: Snow depth, snow cover area, passive microwave, DMRT.

I. INTRODUCTION

Monitoring inter-annual variations in global terrestrial snow cover is important for understanding the role of snow cover in the cryosphere-climate system. While snow cover extent affects the energy budget of the lower atmosphere, the thickness and melt characteristics of snow can affect the dynamics of terrestrial hydrological systems. Estimation of total snow cover volume, therefore, is of great interest not only to climatologists but also to river basin water resource managers who need timely information about snowpack volume and condition (stable or melting) for effective runoff prediction.

Remote sensing has been used to monitor continental-scale snow cover area extent in the northern hemisphere for almost 25 years[1]. The methods available to map snow cover area have begun to mature in the last few years with the availability of Terra and Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) imagery[3] and through the continued development of the National and Oceanic Atmospheric Administration's (NOAA) Interactive Multi-sensor Snow and Ice Mapping System (IMS)[4]. With improved satellite instruments, snow cover extent at regional and local scales can now be mapped effectively. However, while the theory of the estimation of snow depth (SD) or snow water equivalent (SWE) is understood[5], actual practical applications to estimate SD or SWE are still in a development stage; estimation errors are often large[6] especially for retrievals conducted at the global scale. An important reason for these large errors is because historically, algorithms to estimate SD or SWE have been formulated using spatially and temporally static calibration parameters which characterize the parameters in terms of seasonal and global "average" snowpack properties. Since snowpack physical properties (snow density, grain size distribution, stratigraphy etc) are rarely homogenous in space and time, there is a need to make these retrieval algorithms more dynamic in application.